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CLAIMS (76)

1. A turbocharged internal combustion engine comprising:

a variable volume combustion chamber;

inlet valve means controlling flow of air into the combustion chamber;

fuel delivery means for delivering fuel into the air to be mixed therewith;

exhaust valve means for controlling flow of combusted gases from the combustion chamber;

compressor means for compressing the air prior to admission of the air into the combustion chamber;

actuator means for opening and closing the exhaust valve means; and

an electronic controller which controls operation of the actuator means to thereby control opening and closing of the exhaust valve means, wherein:

the exhaust valve means comprises at least a first exhaust valve connected to a first exhaust duct and at least a second exhaust valve connected to a second exhaust duct separate and independent from the first exhaust duct;

the compressor means comprises a first turbocharger and the first exhaust duct is connected to the first turbocharger so that exhaust gases passing through the first exhaust duct drive the first turbocharger to rotate;

the second exhaust duct bypasses the first turbocharger and the combusted gases flowing through the second exhaust duct are exhausted without passing through the first turbocharger; and

the electronic controller by controlling operation of the actuator means and thereby the opening and closing of

the first and second exhaust valves is operable to control what proportion of the combusted gases leaving the combustion chamber flow through each of the first and second exhaust ducts;

the compressor means comprises additionally a second turbocharger;

the first turbocharger is a high pressure turbocharger which can receive compressed air at a first pressure from the second turbocharger, which is a low pressure turbocharger, and the first turbocharger compresses the air to a second higher pressure; and

combusted gases leaving the first turbocharger after expansion in a turbine thereof are combined with the combusted gases flowing in the second exhaust duct and then the combined flow of combusted gases drive the second turbocharger to rotate.

2. A turbocharged internal combustion engine as claimed in claim 1 wherein combusted gases leaving the second turbocharger flow through a catalytic converter and then to atmosphere.

3. A turbocharged internal combustion engine as claimed in claim 1 or claim 2 comprising additionally a first intercooler through which air compressed in the second low pressure turbocharger passes before reaching the first high pressure turbocharger.

4. A turbocharged internal combustion engine as claimed in any one of claims 1 to 3 comprising additionally an intake air bypass passage through which air compressed by

the second turbocharger can flow to the intake valve means bypassing the first turbocharger and bypass valve means controlling flow of the compressed air through the bypass passage.

5. A turbocharged internal combustion engine comprising:

a variable volume combustion chamber;

inlet valve means controlling flow of air into the combustion chamber;

fuel delivery means for delivering fuel into the air to be mixed therewith;

exhaust valve means for controlling flow of combusted gases from the combustion chamber;

compressor means for compressing the air prior to admission of the air into the combustion chamber;

actuator means for opening and closing the exhaust valve means; and

an electronic controller which controls operation of the actuator means to thereby control opening and closing of the exhaust valve means, wherein:

the exhaust valve means comprises at least a first exhaust valve connected to a first exhaust duct and at least a second exhaust valve connected to a second exhaust duct separate and independent from the first exhaust duct;

the compressor means comprises a first turbocharger and the first exhaust duct is connected to the first turbocharger so that exhaust gases passing through the first exhaust duct drive the first turbocharger to rotate;

the second exhaust duct bypasses the first turbocharger and the combusted gases flowing through the second exhaust duct are exhausted without passing through the first turbocharger;

the electronic controller by controlling operation of the actuator means and thereby the opening and closing of the first and second exhaust valves is operable to control what proportion of the combusted gases leaving the combustion chamber flow through each of the first and second exhaust ducts;

the compressor means comprises additionally a supercharger;

the first turbocharger is a low pressure turbocharger which compresses intake air to a first pressure;

the supercharger is a high pressure supercharger which compresses the compressed air output by the first turbocharger to a second pressure higher than the first pressure;

the compressor means comprises additionally a bypass passage through which compressed air compressed by the first turbocharger can bypass the supercharger; and

bypass valve means is provided to control flow of compressed air through the bypass passage.

6. A turbocharged internal combustion engine as claimed in Claim 11 wherein the bypass valve is an electrically-controlled valve controlled by the electronic controller.

7. A turbocharged internal combustion engine comprising:

a variable volume combustion chamber;

inlet valve means controlling flow of air into the combustion chamber;

fuel delivery means for delivering fuel into the air to be mixed therewith;

exhaust valve means for controlling flow of combusted gases from the combustion chamber;

compressor means for compressing the air prior to admission of the air into the combustion chamber;

actuator means for opening and closing the exhaust valve means; and

an electronic controller which controls operation of the actuator means to thereby control opening and closing of the exhaust valve means, wherein:

the exhaust valve means comprises at least a first exhaust valve connected to a first exhaust duct and at least a second exhaust valve connected to a second exhaust duct separate and independent from the first exhaust duct;

the compressor means comprises a first turbocharger and the first exhaust duct is connected to the first turbocharger so that exhaust gases passing through the first exhaust duct drive the first turbocharger to rotate;

the second exhaust duct bypasses the first turbocharger and the combusted gases flowing through the second exhaust duct are exhausted without passing through the first turbocharger;

the electronic controller by controlling operation of the actuator means and thereby the opening and closing of the first and second exhaust valves is operable to control what proportion of the combusted gases leaving the combustion chamber flow through each of the first and second exhaust ducts;

the compressor means comprises additionally an electrically-driven compressor and the first turbocharger is a high pressure turbocharger which receives compressed air compressed by the electrically-driven compressor and pressurises the air to a higher level;

the compressor means comprises additionally a bypass passage through which air can bypass the electrically-driven compressor to flow directly to the turbocharger;

an electrically-controlled bypass valve is provided to control flow of air through the bypass passage; and

the controller controls operation of the bypass valve and the electrically-driven compressor such that the electrically-driven compressor is operated only on starting the engine and/or at low engine speeds and otherwise intake air bypasses the electrically-driven compressor completely and is compressed only by the turbocharger.

8. A turbocharged internal combustion engine comprising:

a variable volume combustion chamber;

inlet valve means controlling flow of air into the combustion chamber;

fuel delivery means for delivering fuel into the air to be mixed therewith;

exhaust valve means for controlling flow of combusted gases from the combustion chamber;

compressor means for compressing the air prior to admission of the air into the combustion chamber;

actuator means for opening and closing the exhaust valve means; and

an electronic controller which controls operation of the actuator means to thereby control opening and closing of the exhaust valve means, wherein:

the exhaust valve means comprises at least a first exhaust valve connected to a first exhaust duct and at least a second exhaust valve connected to a second exhaust duct separate and independent from the first exhaust duct;

the compressor means comprises a first turbocharger and the first exhaust duct is connected to the first turbocharger so that exhaust gases passing through the first exhaust duct drive the first turbocharger to rotate;

the second exhaust duct bypasses the first turbocharger and the combusted gases flowing through the second exhaust duct are exhausted without passing through the first turbocharger;

the electronic controller by controlling operation of the actuator means and thereby the opening and closing of the first and second exhaust valves is operable to control what proportion of the combusted gases leaving the combustion chamber flow through each of the first and second exhaust ducts;

the compressor means comprises a second low pressure turbocharger which compresses air to a first pressure and the first turbocharger is a high pressure turbocharger which compresses air compressed by the low pressure turbocharger to a second pressure higher than the first pressure;

the first exhaust duct relays exhaust gas to the first high pressure turbocharger to drive the high pressure turbocharger to rotate and the second exhaust duct relays exhaust gas to the second lower pressure turbocharger, bypassing the first high pressure turbocharger, to drive the second low pressure turbocharger to rotate; and

the controller controls operation of the actuator means to control what proportion of combusted gases flowing from the combustion chamber flow through the first exhaust duct and what proportion flow through the second exhaust duct, the controller thereby controlling operation

of the first high pressure and the second low pressure turbochargers.

9. A turbocharged internal combustion engine as claimed in claim 8 wherein the expanded exhaust gases leaving the first high pressure turbocharger are fed into the second exhaust duct to be relayed to the second low pressure turbocharger.

10. A turbocharged internal combustion engine as claimed in claim 8 or claim 9 wherein the compressor means comprises additionally a bypass passage through which air can bypass the first high pressure turbocharger and a bypass valve controlling flow of air through the bypass passage.

11. A turbocharged internal combustion engine as claimed in claim 10 wherein the bypass valve is controlled by the electronic controller.

12. A turbocharged internal combustion engine as claimed in any one of claims 5 to 11, wherein the compressor means comprises additionally an intercooler for cooling the compressor intake air prior to delivery of the air into the combustion chamber.

13. A turbocharged internal combustion engine as claimed in one of claims 1 to 12, which comprises additionally a starting valve controlled by the electronic controller which can prevent flow of exhaust gases through the second exhaust duct during engine starting and wherein:

exhaust gases leaving the turbocharger supplied by the first exhaust duct are fed into the second exhaust duct upstream of the starting valve; and

the electronic controller during starting of the engine operates to close the starting valve and to open and close the exhaust valve means so that compressed gases leaving the combustion chamber are relayed via the first exhaust duct to the first turbocharger connected thereto to drive the said first turbocharger and then are returned to the combustion chamber via the second exhaust duct to be compressed again in the combustion chamber.

14. A turbocharged internal combustion engine as claimed in any one of claims 1 to 12 comprising additionally a storage tank, a storage tank passage leading from the combustion chamber to the storage tank and cylinder head storage tank valve means controlling flow of combusted gases to the storage tank from the combustion chamber and also flow of stored combusted gases from the storage tank to the combustion chamber, whereby combusted gases compressed in the combustion chamber can be relayed to the storage tank for storage therein and for later return to the cylinder for expansion therein.

15. A turbocharged internal combustion engine as claimed in any one of the preceding claims wherein the injector means can inject fuel into the combustion chamber early enough in an upstroke for mixing of the fuel with air to produce a homogeneous mixture which is then ignited by homogeneous charge compression ignition and wherein the injection means can alternatively inject fuel later in the

upstroke for compression ignition in the combustion chamber.

16. A turbocharged internal combustion engine as claimed in claim 15 wherein in part load operating conditions of the engine the controller operates to close the exhaust valve means during the upstroke of the piston in order to trap combusted gases in the combustion chamber, the trapped combusted gases forming a mixture with the fuel and air and serving to delay ignition of the fuel and air mixture when the engine is operating with homogeneous charge compression ignition.

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